Announcements

- Homework for tomorrow…

  Ch. 32: Probs. 10, 13, & 14

  CQ1: a) not affected b) not affected (or weakly attracted)
  CQ4: out of page
  CQ5: down

- Office hours…

  MW 10-11 am
  TR 9-10 am
  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm
  F 8-11 am, 2-5 pm
  Su 1-5 pm

Chapter 32

The Magnetic Field

(*The Magnetic Field of a Current*)

Review…

Biot-Savart Law…

$$\vec{B}_q = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

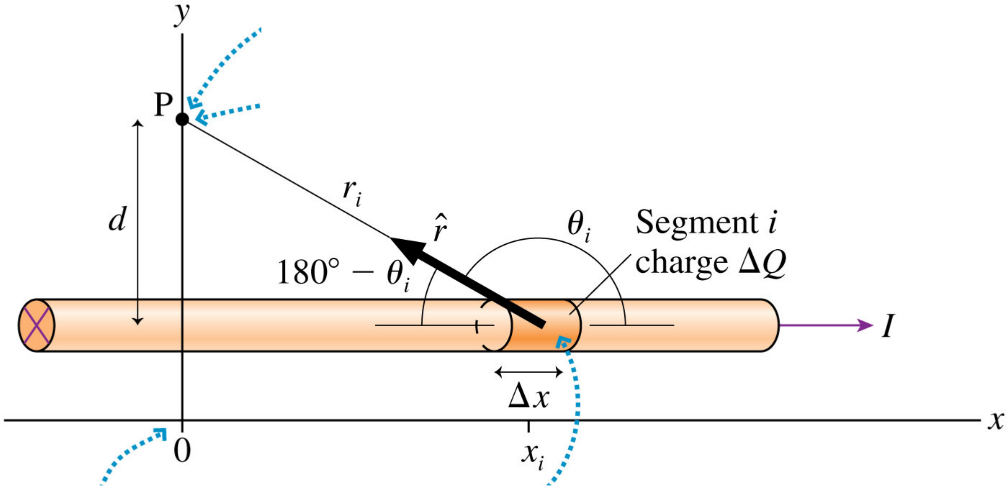
The *B*-field of a *short* segment of current is..

$$\vec{B}_{I\ seg} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{s}\times\hat{r}}{r^2}$$

i.e. 32.3: The *B*-field of a long, straight wire

A long, straight wire carries current I in the positive x-direction.

Find the B-field of a point that is distance d from the wire.



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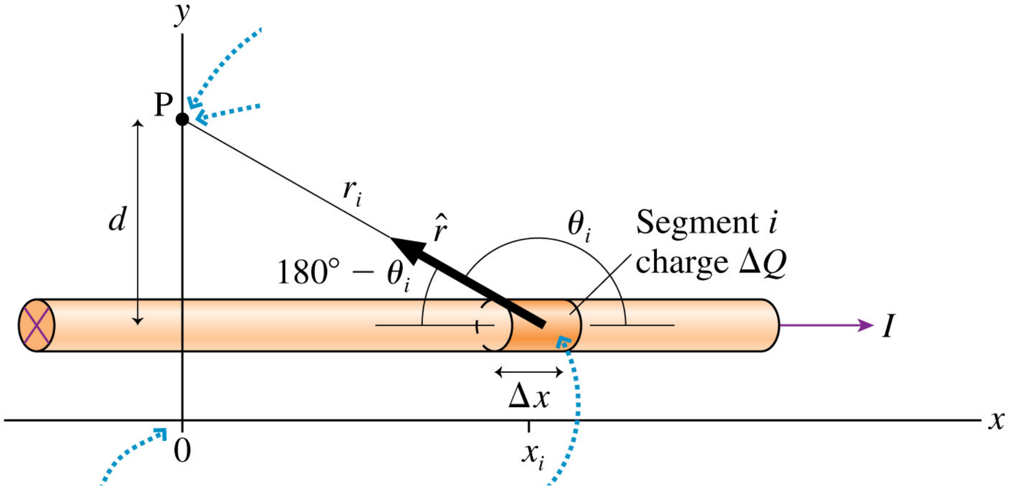
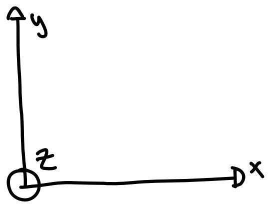


$$B_{wire} = \frac{\mu_0 I}{2\pi d}$$



$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\, d\vec{s}\times\hat{r}}{r^2}$$

$$d\vec{s} = dx\,\hat{\imath}$$

$$I\,d\vec{s}\times\hat{r} = I\,dx\sin\theta\,\hat{k}$$

$$\sin\theta = \sin(180° - \theta) = \frac{d}{r} = \frac{d}{\sqrt{d^2+x^2}}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,dx\sin\theta}{r^2}\hat{k}$$

$$\frac{\mu_0 I}{4\pi}\frac{d}{\sqrt{d^2+x^2}}\frac{dx\,\hat{k}}{d^2+x^2}$$

$$\frac{\mu_0 I d}{4\pi}\frac{dx}{(d^2+x^2)^{3/2}}\hat{k}$$

$$\vec{B} = \int_{-\infty}^{\infty}\frac{\mu_0 I d}{4\pi}\frac{dx}{(d^2+x^2)^{3/2}}\hat{k}$$

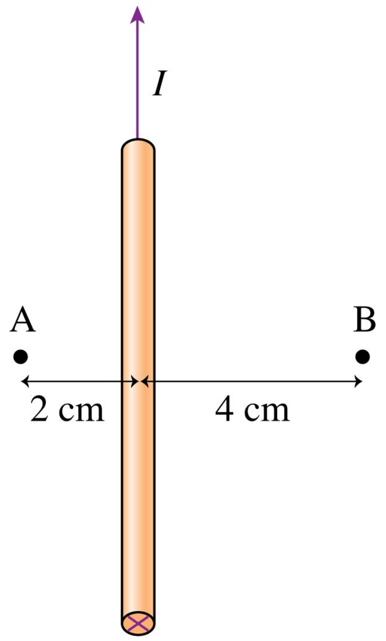
$$= \frac{\mu_0 I d}{4\pi}\hat{k}\int_{-\infty}^{\infty}\frac{dx}{(d^2+x^2)^{3/2}}$$

$$\int\frac{dx}{(d^2+x^2)^{3/2}} = \frac{x}{d^2\sqrt{d^2+x^2}}$$

$$\frac{\mu_0 I d}{4\pi}\hat{k}\left.\frac{x}{d^2\sqrt{d^2+x^2}}\right|_{-\infty}^{\infty} = \frac{\mu_0 I}{4\pi d}\hat{k}(2) = \frac{\mu_0 I}{2\pi d}$$

Quiz Question 1

Compared to the magnetic field at point *A*, the magnetic field at point *B* is



1. Half as strong, same direction.
2. Half as strong, opposite direction.
3. One-quarter as strong, same direction.
4. One-quarter as strong, opposite direction.
5. Can't compare without knowing *I*.

i.e. 32.4:
The *B*-field strength near a heater wire

A 1.0 m long, 1.0 mm diameter nichrome heater wire is connected to a 12 V battery.

What is the *B*-field strength 1.0 cm away from the wire?

$l = 1.0\,m$

$r = 5.0\times10^{-4}\,m$

$\Delta V = 12\,V$

$d = 1.0\times10^{-2}\,m$

$$R = \frac{\rho L}{A} = \frac{(1.5\times10^{-6}\,\Omega m)(1.0\,m)}{\pi(5.0\times10^{-4}\,m)^2} = 1.9\,\Omega$$

$$I = \frac{\Delta V}{R} = \frac{12\,V}{1.9\,\Omega} = 6.3\,A$$

$\Delta V = 12\,V$

$R = 1.9\,\Omega$

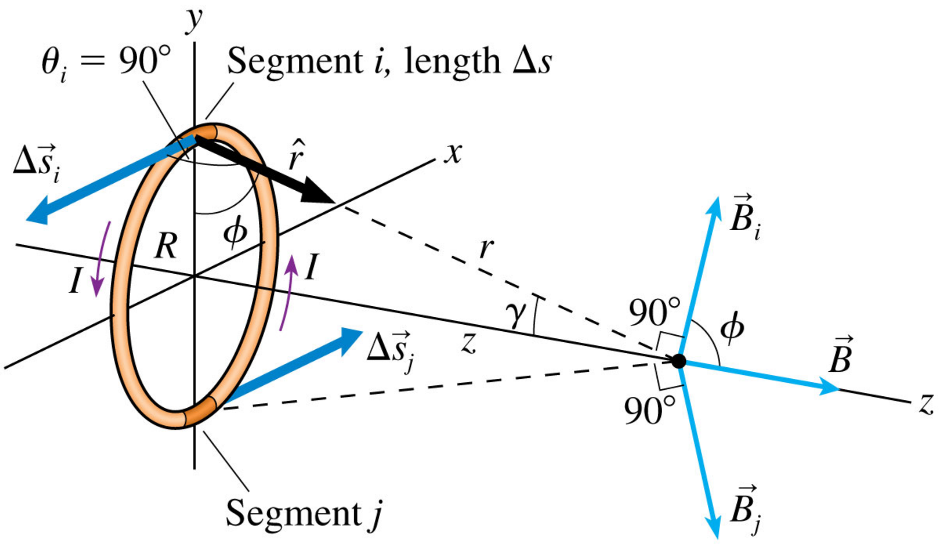
$$B = \frac{(4\pi\times10^{-7}\,Tm/A)(6.3\,A)}{2\pi(1.0\times10^{-2}\,m)}$$

$$B = 1.3\times10^{-4}\,T$$

i.e. 32.5: The *B*-field of a current loop

The figure below shows a current loop, a circular loop of wire with radius R that carries current I.

Find the B-field of the current loop at distance z on the axis of the loop.

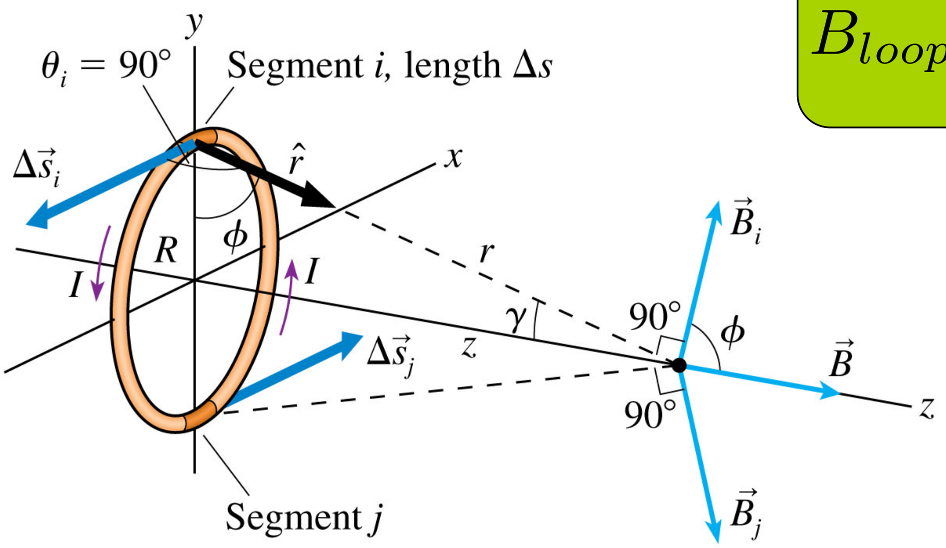


i.e. 32.5:
The B-field of a current loop

The figure below shows a current loop, a circular loop of wire with radius R that carries current I.

Find the B-field of the current loop at distance z on the axis of the loop.

$$B_{loop} = \frac{\mu_0}{2}\frac{IR^2}{(z^2+R^2)^{3/2}}$$



$$d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{s}\times\hat{r}}{r^2} \qquad |I\,d\vec{s}\times\hat{r}| = I\,ds\sin(90°) = I\,ds$$

$$dB_z = dB\cos\phi = \frac{\mu_0 I\,ds}{4\pi r^2}\cdot\frac{R}{r} = \frac{\mu_0 I}{4\pi}\frac{R}{r^3}ds$$

$$\cos\phi = \frac{R}{r}$$

$$B_z = \int\frac{\mu_0 I}{4\pi}\frac{R}{r^3}ds$$

$$B_z = \frac{\mu_0 I}{4\pi}\frac{R}{r^3}\int ds = \frac{\mu_0 I}{4\pi}\frac{R}{r^3}2\pi R$$

$$\frac{\mu_0 I}{2}\frac{R^2}{r^3} = \frac{\mu_0 I}{2}\frac{R^2}{(R^2+z^2)^{3/2}}$$

i.e. 32.5: The B-field of a current loop

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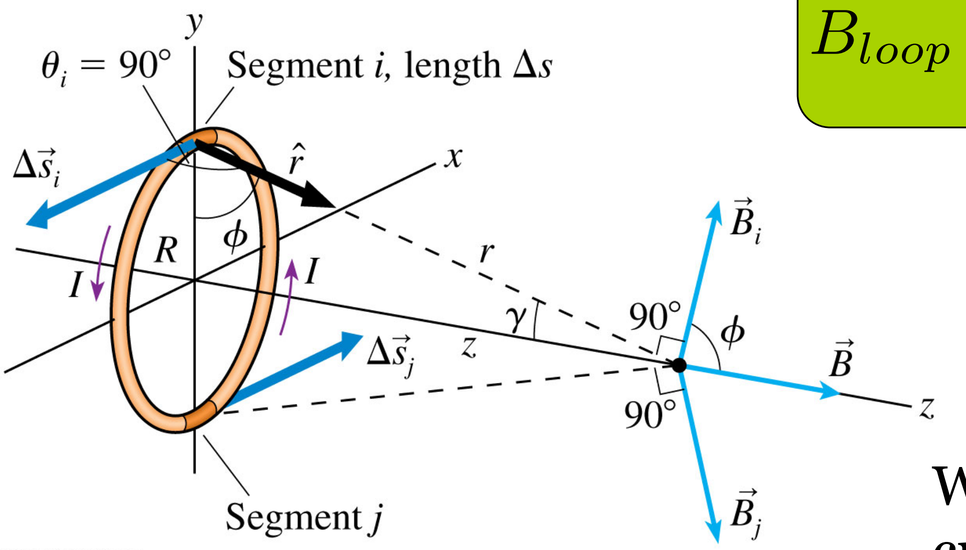
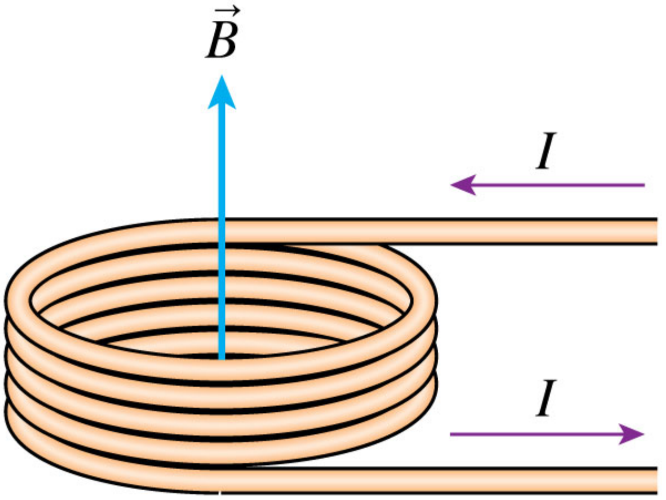


What's the B-field at the current loop's center?

The *B*-field of a… *coil* consisting of *N* turns of wire…

$$B_{coil\ center} = \frac{\mu_0}{2}\frac{NI}{R}$$



Valid when the turns are all *very* close together,
so that the *B*-field of each is essentially the *same*.